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DWG NO. 201027457

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SOURCE CONTROL DRAWING

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCE ON: FRACTIONS DECIMALS ANGLES ± .XX± ± .XXX±	DFTSMN STEVE RANSOM	DATE 12/04/16	U.S. AIR FORCE			
	CHKR RODNEY GOULD	12/05/01	TITLE Solutions For Use In LHE Zinc – Nickel Plating On High Strength Steel Substrate (>180 KSI) Landing Gear Components			
	MATL ENGR N/A					
	PROJ ENGR DAVE FREDERICK	12/04/30				
CURRENT CAGE CODE	A.F. AUTHENTICATION RON MONTGOMERY	12/04/30	SIZE A	CAGE CODE 98747	DWG NO. 201027457	REV
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EF (MS WORD)

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1 SCOPE

1.1 Purpose

This specification covers acceptance criteria for solutions to be used for the deposition of a zinc-nickel coating and subsequent treatment of the coating on ultra high strength steel (180,000 psi (180 ksi) and above) utilizing a Low Hydrogen Embrittling alkaline zinc-nickel (Zn-Ni) electroplating process with a trivalent chrome or chromium free conversion coat. The process shall be applied directly to the base metal without the use of a base coat plating strike consisting of materials other than the plating solution being used.

1.2 Classification

Class 1	0.013mm (0.0005 inch) thick minimum
Class 2	0.008mm (0.0003 inch) thick minimum
Class 3	0.005mm (0.0002 inch) thick minimum

1.2.1 Types

Plating covered by this specification is classified as follows:

Type I	As-plated without supplementary treatment
Type II	As-plated with supplementary trivalent chromium conversion coat treatment.

2 REQUIREMENTS

2.1 Qualification

The plating and post treatment materials furnished under this specification shall be products that are authorized by the qualifying activity for listing on the applicable qualified products list before contract award.

2.2 Coating Materials

Zinc-Nickel Alloy. Trivalent or Chromium Free Conversion Coat

2.3 Application

High strength steel landing gear components > 180 KSI. The process shall be capable of relieving the hydrogen resulting from processing by baking at 375 +/- 25 degrees F for no longer than 23.0 hours (reference 2.5.1).

2.4 Toxicity

The material and processing baths or solutions shall have no adverse effect on the health of personnel (see 4.3), when used for the intended purpose in accordance with (IAW) local process specifications.

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NONE	4		

2.5 Performance Characteristics

2.5.1 Embrittlement

Qualification test specimens shall be subjected to a sustained load test at 75 percent of the ultimate notched tensile strength. The specimens shall endure this sustained load for 200 hours minimum without failing or cracking when tested in accordance with section 3.2.4. Upper and lower levels of vendors recommended composition and current density ranges shall be tested in accordance with Table 1 to insure no embrittlement at varying bath compositions.

Table 1: Composition/Current Density Ranges

Compositions	Current Density Ranges			Total Number of Coupons
	Low	Middle	High	
High Zn/High Ni	8	8	8	24
High Zn/Low Ni	8	8	8	24
Low Zn/High Ni	8	8	8	24
Low Zn/Low Ni	8	8	8	24
Med Zn/Med Ni	8	8	8	24

2.5.2 Re-Embrittlement

Test specimens shall be tested in the aqueous cleaning fluids by two methods, see Table 2. The first defined by USAF Drawing 9825019 specifies a 30 minute immersion at the maximum recommended temperature after which the coupons are then dried and tested at 75% NFS for 200 hours. The second method requires loading the coupons under constant room temperature fluid immersion at 45% NFS for 150 hours. The specimens shall endure the sustained loads without failing or cracking when tested in accordance with section 3.2.5.

Table 2: Re-Embrittlement Test Matrix

Test Temperature	Current Aqueous Cleaners		
	Room Temp	Max Use Temp of Cleaner	Total Quantity
HE Test Method	45% NFS for 150 Hrs	Dwg 9825019, Note 6	
Zn-Ni Coupons Per Cleaner	8	8	16

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2.5.3 Corrosion Resistance

After testing in accordance with 3.2.1 for applicable salt spray exposure hours as specified in Table 3, the specimens shall show no evidence of white corrosion or red rust. Areas within 0.25 inch (6.35 millimeters [mm]) from the edges of the panel, the identification markings, and the panel holding points during processing or salt spray exposure shall not be evaluated. Differences in color between the test panels and the control panels shall not be cause for rejection.

2.5.3.1 Type I

Coatings shall show no evidence of red rust corrosion products in controlled thickness areas when exposed to salt spray for 1000 hours in accordance with ASTM B117. Corrosion products around the edges of the specimen shall not constitute failure.

2.5.3.2 Type II

Coatings shall show no evidence of white corrosion products after 96 hours and no evidence of red corrosion on the basis metal in controlled thickness areas after 1000 hours when tested by continuous exposure to the salt spray in accordance with ASTM B117. Corrosion products around the edges of the specimens shall not constitute failure.

Table 3: Schedule for corrosion resistance properties

Corrosion Resistance Inspection	Minimum Number of Panels	Plating Thickness	Type	Material To Be Coated	Salt Spray Exposure (Hours)	Salt Spray Exposure (Hours)
Qualification	12	Class 3	I	4130 Steel	96	1000
Qualification	12	Class 3	II	4130 Steel	96	1000

2.5.4 Adhesion

Adhesion of the zinc-nickel coating shall be tested IAW ASTM B571 and this specification section 3.2.3. All classes shall be tested to verify adhesion throughout the range of thicknesses. 8 panels per class shall be tested.

2.5.5 Fatigue

Fatigue coupons shall be tested IAW ASTM E466 and be manufactured according to the drawing in this specification section 3.2.5. Coupons shall be manufactured from 300M (Figure 2), heat-treated to 1930 - 2068 MPa (280-300 ksi) in accordance with AMS-H-6875 and tested at the stress loads in Table 4 and Table 5. Fatigue data shall be reviewed by the procuring ALC cognizant engineering group and shall show no statistical difference in fatigue performance as compared to baseline cadmium plated fatigue coupons.

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NONE	6		

Table 4: Unpeened Fatigue Test Matrix

Unpeened coupons	R= -0.5	Stress Loads (KSI) R= -0.3			Total Quantity
	150	160	180	200	
Bare	5	5	5	5	20
Zn-Ni Plated Tri Chrome	5	5	5	5	20
Spares	5	5	5	5	20
Total Fatigue Coupons					60

Table 5: Shotpeened Fatigue Test Matrix

Peened coupons	R= -0.5	Stress Loads (KSI) R= -0.3			Total Quantity
	150	160	180	200	
Bare	5	5	5	5	20
Zn-Ni Plated Tri Chrome	5	5	5	5	20
Spares	5	5	5	5	20
Total Fatigue Coupons					60

2.5.6 Brush Plate

The vendor shall verify that the no-bake brush plating zinc-nickel from solutions qualified to AMS 2451/9 will adhere to the zinc-nickel deposit when tested in accordance with Section 3.2.7.

2.5.7 Paint Adhesion

Panels shall be tested IAW ASTM D3359 and shall show no signs of peeling when coated with MIL-PRF-85582 epoxy primer. All panels shall undergo testing in both dry and wet conditions as defined in ASTM D3359.

Table 6: Paint Adhesion Test Matrix

Paint Adhesion Inspection	Minimum Number of Panels	Plating Thickness	Type	Material To Be Coated
Qualification	6	Class 3	II	4130 Steel

2.5.8 Control Factors

The vendor shall supply processing and control information. Such information shall include, but not be limited to the following:

- Surface preparation including strike, if used (this strike refers to a high current density plating strike in the same zinc-nickel solution used for plating).
- Detailed processing procedures
- Plating bath composition and composition control limits

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NONE	7		

- Analytical procedures
- Impurities limits
- Impurities treatment procedures
- Impurity removal treatments

2.5.9 Finish Quality

This is a visual examination of the coupon after it has completed the plating process. The deposit shall be smooth, continuous, adherent to the basis metal, and visually free from porosity, blisters, nodules, pits, and other imperfections detrimental to performance of the plating. Slight staining or discoloration is permissible.

2.5.10 Process Validation

Government reserves the right to require additional prototype testing to demonstrate long term robustness of processes as well as compatibility with current conforming anode fixture designs.

2.5.11 Zn-Ni Stripping Method

Zn-Ni coating shall be able to be stripped in a solution of ammonium nitrate at 16 ounces per gallon in water. The pH levels should be maintained between a range of 8.0 to 9.0 using sodium hydroxide. Stripping times shall not exceed 60 minutes at a temperature of 21 – 27°C (70 – 80°F) when plated to a class 1 thickness.

Table 7: Stripping Procedure Test Matrix

Stripping Methods	Minimum Number of Panels	Plating Thickness	Type	Material To Be Coated
Qualification	4	Class 1	II	4130 Steel

3 TEST METHODS

3.1 Responsibility for Inspection

The processor shall supply all samples for processor's tests and shall be responsible for the performance of all required tests.

3.2 Required Testing

These are listed by test and requirement paragraph:

Corrosion resistance, Type I and II (3.2.1)

Current Density vs. Composition (3.2.2)

Adhesion (3.2.3)

Hydrogen embrittlement (3.2.4)

Re-Embrittlement (3.2.5)

Fatigue (3.2.6)

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NONE	8		

Brush Plating (3.2.7)
Paint Adhesion (3.2.8)
Stripping Procedure (3.2.9)

3.2.1 Corrosion Resistance

Test panels for corrosion resistance shall be new, unused panels of 4130 steel approximately 1.0 x 102 x 153 mm (0.040 x 4 x 6 inches). They shall be prepared for and plated using the same procedures specified for production parts. Coating thickness and composition shall be determined for each test panel using the same test procedure as used on production parts. Test panels shall be plated to Class 3 0.0508 - 0.1016mm (0.0002 – 0.0003 inches). The test panels shall then be baked for no more than 23 hours at $190.5 \pm 13.9^{\circ}\text{C}$ ($375 \pm 25^{\circ}\text{F}$). The test panels shall meet all criteria as listed in section 2.5.3.

3.2.2 Current Density vs. Composition

Test shall be performed on corrosion panels prior to testing. Eight points of the corrosion panels shall be selected such that the composition across the entire panel is measured. Recommended points are shown in Figure 1. Composition shall be determined by X-ray Fluorescence (XRF) or by a method acceptable to the purchaser and shall be uniform across the entire panel with coating in the 12-17 percent nickel composition range.

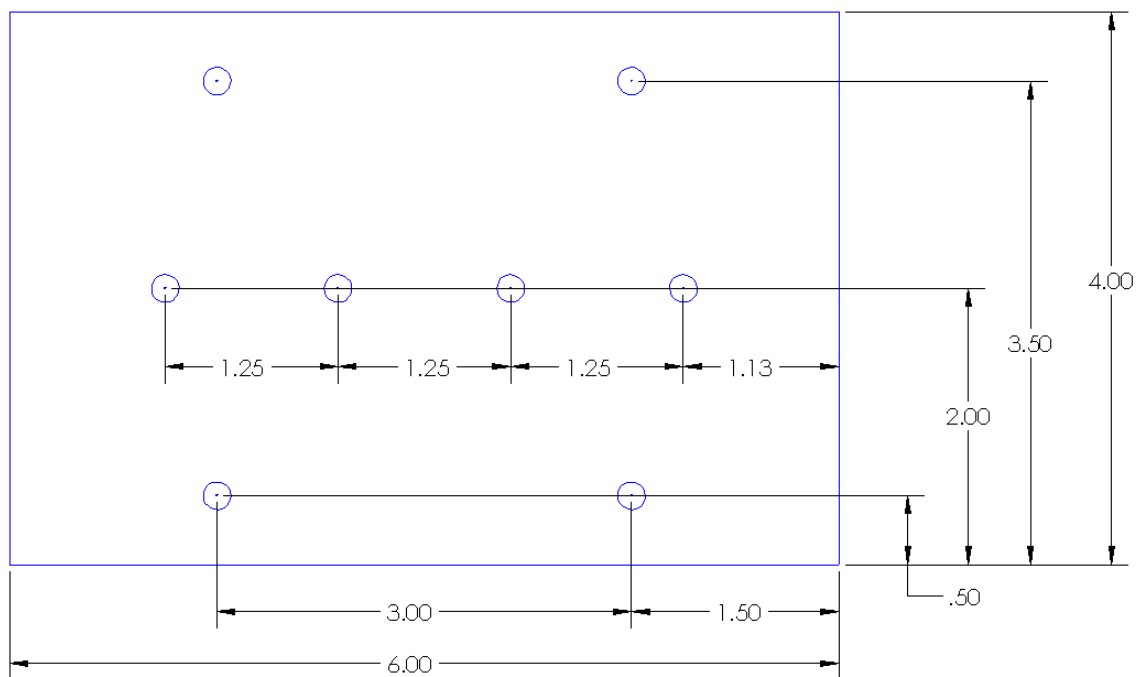


Figure 1: Recommended Composition Test Points

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SCALE	SHEET		
NONE	9		

3.2.3 Adhesion

Test panels for adhesion shall be new, unused panels of 4130 steel approximately 1.0 x 25 x 102 mm (0.040 x 1 x 4 inches). They shall be prepared for and plated using the same procedures specified for production parts. The test panels shall be baked for no more than 23 hours at $190.5 \pm 13.9^{\circ}\text{C}$ ($375 \pm 25^{\circ}\text{F}$). They shall then be clamped in a vise and repeatedly bent through approximately 90 - 180 degrees until rupture of the basis metal and/or plating occurs then examined at 4X magnification for lifting of the deposit along the broken edge. Lifting of the deposit shall constitute failure.

3.2.4 Hydrogen Embrittlement Relief Test

3.2.4.1 Embrittlement Test

The processor shall demonstrate the ability to provide a zinc-nickel plate which meets the requirements of paragraph 2.5.1 of this drawing as follows:

a. Round notched 1a.1 4340 steel specimens per ASTM F519.

b. The specimens shall be prepared for and plated using the same procedures specified for production parts. During plating the specimens shall be mounted symmetrically on a rack by themselves. All areas of the rack except the contact area shall be coated with a suitable masking. An ammeter having a sensitivity of 0.5 amperes or better shall be connected between the specimen rack and the cathode. The specimens shall be plated to a thickness of 0.015 to 0.020mm (0.0006 to 0.0008 inch). The specimens shall be baked for no more than 23 hours at $190.5 \pm 13.9^{\circ}\text{C}$ ($375 \pm 25^{\circ}\text{F}$) within four (4) hours of removal from the bath.

c. The specimens shall be subjected to 200 hours of static loading at 75 percent of the ultimate notched tensile strength in accordance with ASTM F519. The test shall be considered passed if all specimens from each composition group meet the requirements of paragraph 2.5.1.

d. Upon successful completion of the static load test, a minimum of 25% of the notched tensile specimens shall be sectioned across the notch parallel to the axis of the specimen. Photomicrographs shall be taken of the notched area and the coating examined at 80 – 100 X magnifications. The coating shall be uniform around the circumference of the notch and the coverage essentially complete. Consideration must be given to the nature of the coating. The coating, under magnification, is rough. There will be voids that may extend to base metal. This shall not be considered as incomplete plating.

e. A complete analysis report of the plating bath with the qualification test results shall be submitted as required by the procuring activity.

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SCALE	SHEET		
NONE	10		

3.2.5 Re-Embrittlement

The processor shall demonstrate the ability to provide a zinc-nickel plate which provides hydrogen re-embrittlement resistance to current aqueous cleaners and meets the requirements of paragraph 2.5.2 of this drawing as follows:

a. Round notched 1a.1 4340 steel specimens per ASTM F519.

b. The specimens shall be prepared for and plated using the same procedures specified for production parts. During plating the specimens shall be mounted symmetrically on a rack by themselves. All areas of the rack except the contact area shall be coated with a suitable masking. An ammeter having a sensitivity of 0.5 amperes or better shall be connected between the specimen rack and the cathode. The specimens shall be plated to a thickness of 0.015 to 0.020mm (0.0006 to 0.0008 inch). The specimens shall be baked for no more than 23 hours at $190.5 \pm 13.9^{\circ}\text{C}$ ($375 \pm 25^{\circ}\text{F}$) within four (4) hours of removal from the bath.

c. The specimens shall be immersed in the cleaning compound at the manufacturer's maximum recommended temperature and appropriate cleaning concentration for 30 minutes. The specimen shall then be removed, air dried and then loaded to 75% of the ultimate notched tensile strength in accordance with ASTM F519. The test shall be considered passed if all specimens from each cleaning compound group meet the requirements of paragraph 2.5.2.

d. The specimens shall be tested under constant room temperature fluid immersion at 45% ultimate notched tensile strength for 150 hours. The test shall be considered passed if all specimens from each cleaning compound group meet the requirements of paragraph 2.5.2

3.2.6 Fatigue Performance

Fatigue coupons shall be tested in accordance with ASTM E466. During plating both of the grip ends shall be masked such that only the gage section of the coupon receives coating. The solution specification will be optimized in that both the upper limits (UL) and lower limits (LL) of the Zn-Ni solution shall be tested. The LL coupons will be coated with the solution in the tank prepared IAW the lower end recommendations in the vendor specification. The solution will then be remixed to the upper recommended limit and the remaining coupons will be coated. In either case, the conversion coating process will be the same. The specimens shall be plated to a thickness of 0.015 to 0.020mm (0.0006 to 0.0008 inch). The specimens shall be baked for no more than 23 hours at $190.5 \pm 13.9^{\circ}\text{C}$ ($375 \pm 25^{\circ}\text{F}$) within four (4) hours of removal from the bath.

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SCALE	SHEET		
NONE	11		

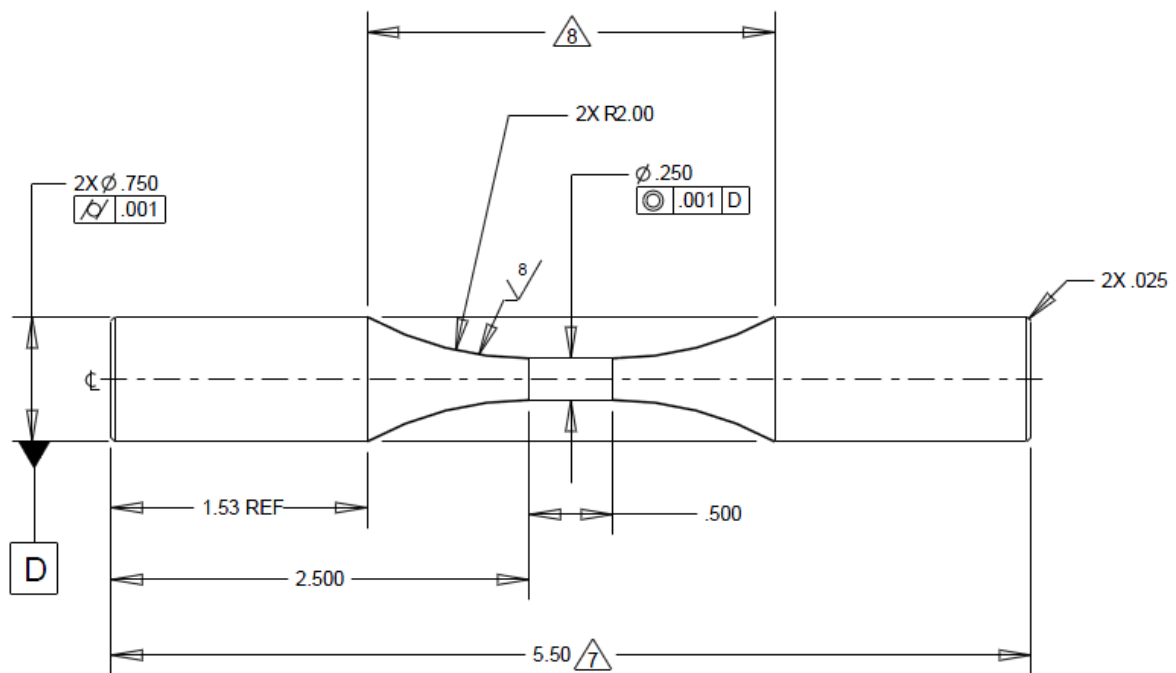


Figure 2: Fatigue Test Coupon

Note: Flag 7 – Shot peen per SAE AMS2430, 8-10A, 100% intensity S230, wrought steel. All shot peening will be computer controlled

Note: Flag 8 – Do not peen area when preparing unpeened coupons for testing.

3.2.7 Brush Plating

Non-hydrogen embrittling plating solutions to be used are listed in the qualified vendor's list (Table 8) and testing shall be performed on 1.0 X 25 X 153 mm (0.040 X 1 X 6 inches) 4130 steel coupons. The coupons shall be prepared by brush plating over Zn-Ni tank plated sections and over a simulated damaged LHE Zn-Ni area IAW the qualified vendors brush plating instructions. The simulated damage area will be created by masking off a 0.5" strip lengthwise down the center of the coupon prior to plating using the standard plating tank. After plating the masking will be removed exposing a bare strip to be brush plated. The masked surface shall be cleaned to remove any adhesive tape residue. All coupons will then be tested and must pass the requirements for adhesion as described in section 3.2.3.

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NONE	12		

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3.2.8 Paint Adhesion

Test panels for paint adhesion shall be new, unused panels of 4130 steel approximately 1.0 x 102 x 153 mm (0.040 x 4 x 6 inches). They shall be prepared for and plated using the same procedures specified for production parts. Coating thickness and composition shall be determined for each test panel using the same test procedure as used on production parts. Test panels shall be plated to Class 3 thickness [0.0508 - 0.1016mm (0.0002 – 0.0003 inches)]. The test panels shall then be baked for no more than 23 hours at 190.5 ± 13.9°C (375 ± 25°F).

Test panels shall be coated with an epoxy primer IAW MIL-PRF-85582D and tested IAW ASTM D3359 after Zn-Ni coating. The primer shall be allowed to air dry at room temperature for 14 days before doing the dry and wet tape adhesion tests. All test panels must meet the requirements as described in section 2.5.7.

3.2.9 Stripping Procedure

Test panels for Zn-Ni stripping procedure shall be new, unused cylindrical coupons of 4130 steel approximately 101 x Ø9.5 mm (4 x Ø0.375 inches). They shall be prepared for and plated using the same procedures specified for production parts. Test coupons shall be plated with Zn-Ni to a minimum coating weight of 0.015 grams of Zn-Ni per square centimeter of plated surface. The coating weight and Zn-Ni composition of the coating shall be recorded and reported. The composition shall be the same as reported for all qualification tests.

Using 1 +/- 0.1 liters of the strip solution, strip a minimum of four specimens comprising a total minimum stripped coating weight of 4.0 grams of Zn-Ni coating. The coating weight remaining after 60 minutes of immersion shall not exceed 1.7×10^{-4} (0.00017) grams per square centimeter of plated surface. All coupons must pass the requirements described in section 2.5.11.

4 NOTES

This section contains information of a general or explanatory with requirement documents that should accompany qualification samples.

4.1 Procurement Documents

4.2 Retention of Qualification

In order to retain qualification of a product approved for listing on the qualified products list (QPL), the manufacturer will verify by certification to the qualifying activity that the manufacturer's product complies with the requirements of this Specification. No significant change will be made in formulation, raw materials or supplier(s) of raw materials, methods of manufacture, equipment, or geographic location without prior written Government approval. A significant change is one which, in the judgment of the cognizant engineering organization, could affect the properties or performance of the parts. The Government reserves the right to re-examine the qualified product whenever deemed necessary to determine that the product continues to meet any or all of the specification requirements.

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4.3 Information Required to Accompany Qualification Samples

When authorizing the forwarding of qualification samples, the qualifying activity will request the manufacturer to submit the qualification inspection sample, the Material Safety Data Sheet (MSDS), and a test report showing that the material conforms to the requirements of this specification. An MSDS must be prepared and submitted in accordance with FED-STD-313. The MSDS must also meet the requirements of 29 CFR 1910.1200. The 29 CFR 1910.1200 requires that the MSDS for each hazardous chemical used in an operation must be readily available to personnel using the material. Questions pertinent to the effect(s) of these plating and conversion coatings on the health of personnel using them can be referred by the procuring activity to the appropriate medical service, who will act as its adviser. Contracting officers will identify the activities requiring copies of the MSDS.

4.4 Conformity to Qualified Sample

All lots of materials supplied under this specification must be manufactured using the same formulation, raw materials and supplier(s) of raw materials, methods of manufacture, equipment, and geographic location as the qualification sample, unless changes have been approved by the qualifying activity.

4.5 Key words:

Electrodeposited
Corrosion resistance

4.6 Drawing prepared IAW ASME Y14.100 including appendices B thru E.

4.7 Interpret dimensioning and tolerancing IAW ASME Y14.5-2009.

4.8 Only items described on this drawing are approved for use in the applications specified hereon. A substitute item shall not be used without prior approval by the qualifying activity.

4.9 Identification of the approved source(s) of supply hereon is not to be construed as a guarantee of present or continued availability as a source of supply for the item described on the drawing.

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NONE	14		

Table 8: Qualified Coating Application Processor's List

CONTROL PART NO.	APPROVED SOURCES OF SUPPLY				
	SUPPLIER DATA				
	CAGE CODE	PART NUMBER	MEETS REQT OF	PRODUCT IDENT.	NAME, ADDRESS AND PHONE NUMBER
-01	4F927	IZ-C17+		IZ-C17+	DIPSOL™ OF AMERICA 34005 SCHOOLCRAFT ROAD LIVONIA, MI 48150 (734) 261-0653
-03	4F927	IZ-264		IZ-264	DIPSOL™ OF AMERICA 34005 SCHOOLCRAFT ROAD LIVONIA, MI 48150 (734) 261-0653
-05	78226	4018		SIFCO 4018 (Zn-Ni Brush Plating)	SIFCO INDUSTRIES, INC. 970 EAST 64 TH STREET CLEVELAND, OH 44103 (216) 881-8600
-07	78226	5030		SIFCO 5030 (Conversion Coating for Zn-Ni Brush Plating)	SIFCO INDUSTRIES, INC. 970 EAST 64 TH STREET CLEVELAND, OH 44103 (216) 881-8600

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